Solar Process Cold & Solar Driven Cold Rooms –

Results from the SOLERA EU project
Current Activities in the AgroKühl project

Michael Berger, 10th July, 2012
San Francisco / USA
Two similar projects

• **Recent: Solera EU project with PSE AG/Industrial Solar GmbH**
  – Demonstration of solar thermal driven cooling in three different systems
  – One of them in Freiburg with a linear Fresnel collector by Industrial Solar
  – **Goals of the system in Freiburg:**
    • cooling temperatures below 0 °C
    • dry heat rejection
    • latent heat storage (ice storage)
    • cascaded operation of smaller chillers
  – **Application:**
    • no real application
    • with electrical heaters any pre-defined load profile can be simulated and tested
  – **Project was finished in late 2011**

• **Current: AgroKühl project**
  – **Application:** solar driven cold room
  – **Industrial Solar** as collector supplier
  – System setup is similar to Solera system, but smaller
  – **Installation started in March 2012,** **Commissioning took place last week**

www.industrial-solar.de
Recent Project
Linear Fresnel Collector

Source: Industrial Solar GmbH
Recent Project Technical Details

- 132 m² Linear Fresnel Collector was built in Freiburg in 2009

- Hybrid System: Operation both possible with pressurised water or in direct steam generation

- Operation pressures up to 16 bar, temperatures up to 200 °C

- Necessary extension of existing plant:
  - 2 Robur chillers, heat exchanger, electrical load and ice storages
  - planned November 2010, installed in early 2011, commissioned June 2011

- Operation and Monitoring since July 2011
Recent Project Technical Details

- 2 Robur water-ammonia chillers total cooling power of 24 kW (rated COP$_{th}$ of 0.6)
- Four Consolar Ice storages total latent heat capacity of 111 kWh (4 x 300 l of water)
- Electric heaters as simulated loads total heating power of 0 .. 30 kW
- Heat exchanger for steam operation (2.8 m$^2$ heat exchanging area)
- Steam drum for steam separation (250 l, lamellar separator)
Pressurised water mode: Test Plan

- Keeping provided temperature at chillers constant: different temperature levels (e.g. 160 °C, 200 °C), control of active collector area
- Collector always with maximum power (all mirrors out or all mirrors in)
- Cooling curve over night (test of heat losses, test of vacua)
- Compare operation of both chillers with cascaded operation (part load behaviour)
- Control variable: Temperature at collector exit
- Actuating variable: Active collector area
Monitoring Results – Pressurised Water

Hochdorf
Date: 2011/09/21

- T_Collector_out [°C]
- T_Collector_in [°C]
- Volume Flow [l/min]
- Efficiency [%]
- Active Collector Area [m²]
- Expected Collector Power [kW]
- DNI [W/m²], right axis

Source: Industrial Solar GmbH
Monitoring Results – Pressurised Water

Freiburg, Date: 2011/09/21

Source: Industrial Solar GmbH

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Monitoring Results – Pressurised Water

SOLERA Subgroup 1, Date: 2011/09/21

Source: Industrial Solar GmbH
Summary and Lessons Learnt

• Collector Power and Efficiency could be measured in Pressurised water operation, results matched expectations

• Ice Storages worked well, but heat exchanger properties could be optimised, conclusion may be:
  – Use larger storage only beyond certain charge level, which would have to be defined by economical optimization

• Chillers showed better part load behaviour in cascaded operation as expected
Current Project: The Cold Room

- Manufacturer: Kramer GmbH
- Area: 32 m²
- Air Volume: 100 m³
- Walls: 120mm Polyurethane Sandwich
- Steel Support Structure completely outside

Source: Kramer GmbH

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Current Project: The Collector

- **Manufacturer:** Industrial Solar GmbH
- **Type:** Linear Fresnel
- **Size:** 88 m² aperture area
- **Location:** rooftop of Kramer’s office building
- **Operation with pressurised water:** 13 bar\(_g\); 180 °C
Current Project: The System

- **Chiller:**
  - Manufacturer: Robur Spa (Italy)
  - Type: Single-Effect Water-Ammonia
  - 12 kW cooling capacity
  - Rated COP 0.6
  - Dry heat rejection integrated

- **Storage:**
  - Manufacturer: Consolar (Germany)
  - Type: Ice storage (PCM)
  - 2 x 300 l water as latent heat storage
  - 55 kWh latent heat capacity

- **Commissioning:** 5th/6th July, 2012

- **Operation and Monitoring within AgroKühl project in 2012+2013.**
Thank you for your attention!

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Source: Industrial Solar GmbH

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